Figure 1

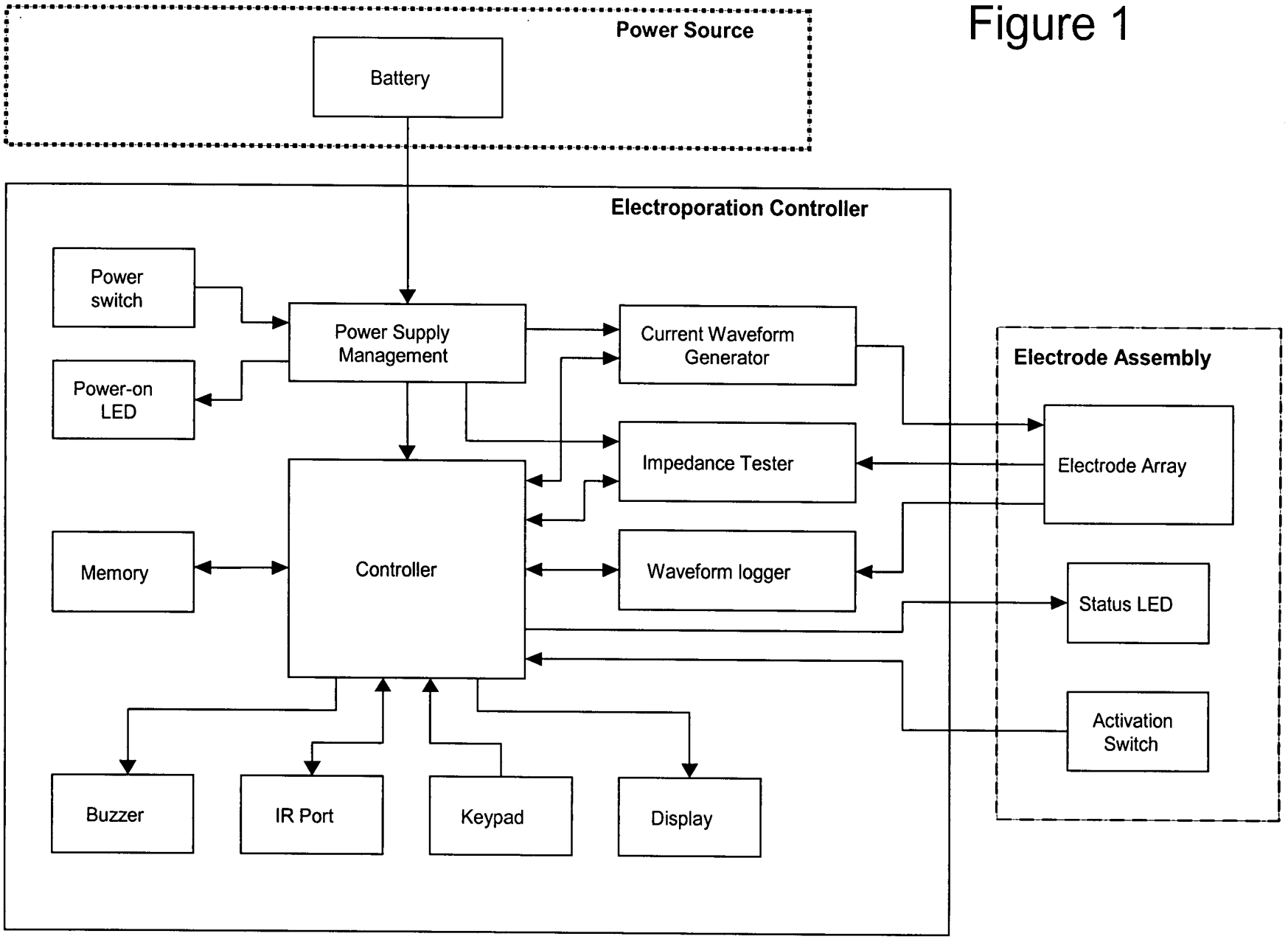

Power Source
Battery
Electroporation Controller
Power switch
Power Supply Management
Current Waveform Generator
Power-on LED
Impedance Tester
Electrode Assembly
Electrode Array
Memory
Controller
Waveform logger
Status LED
Activation Switch
Buzzer
IR Port
Keypad
Display

Figure 2

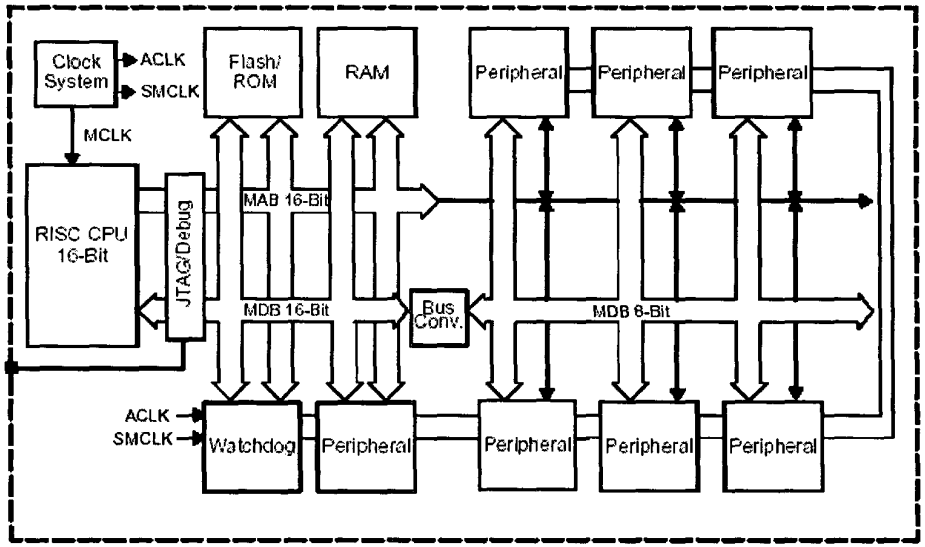

Clock System
ACLK
SMCLK
MCLK
RISC CPU 16-Bit
JTAG/Debug
Flash/ ROM
RAM
MAB 16-Bit
MDB 16-Bit
Bus Conv.
MDB 8-Bit
Peripheral
Peripheral
Peripheral
ACLK
SMCLK
Watchdog
Peripheral
Peripheral
Peripheral
Peripheral

Figure 3

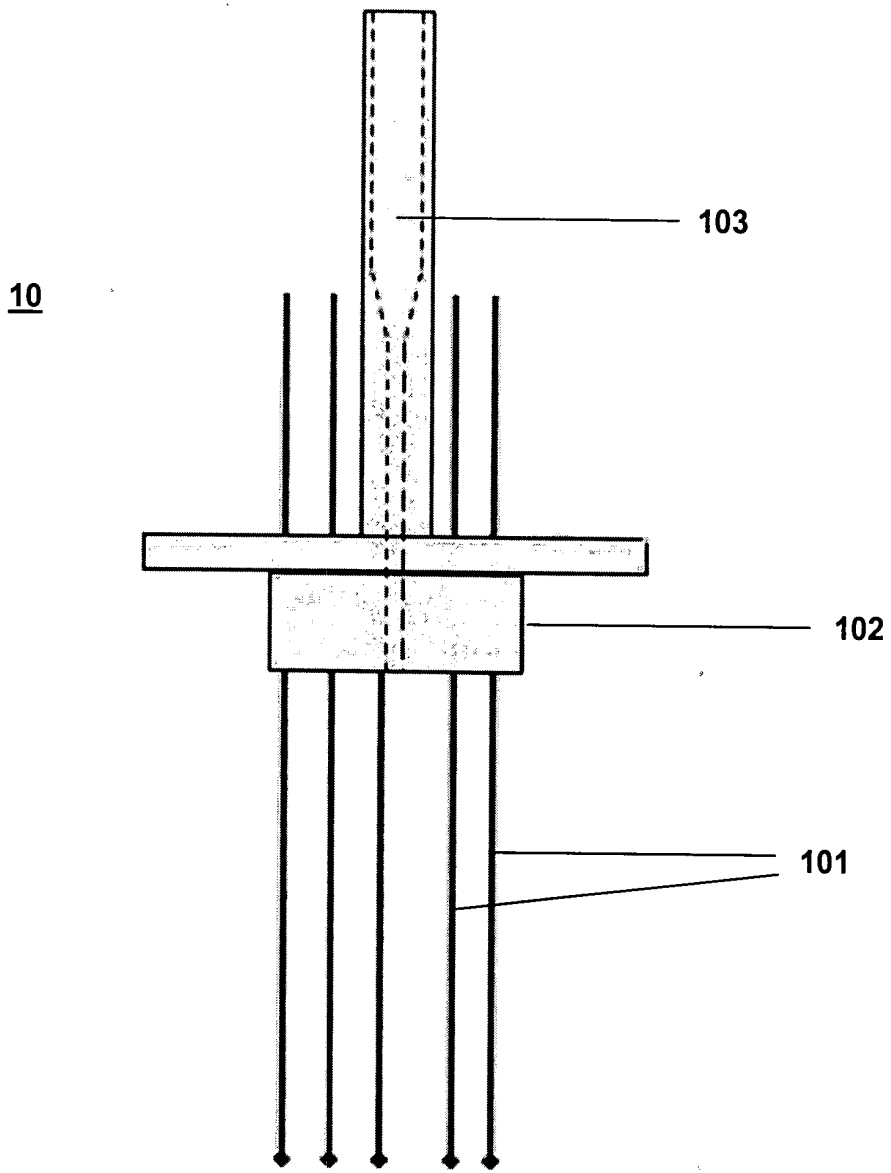


Figure 4

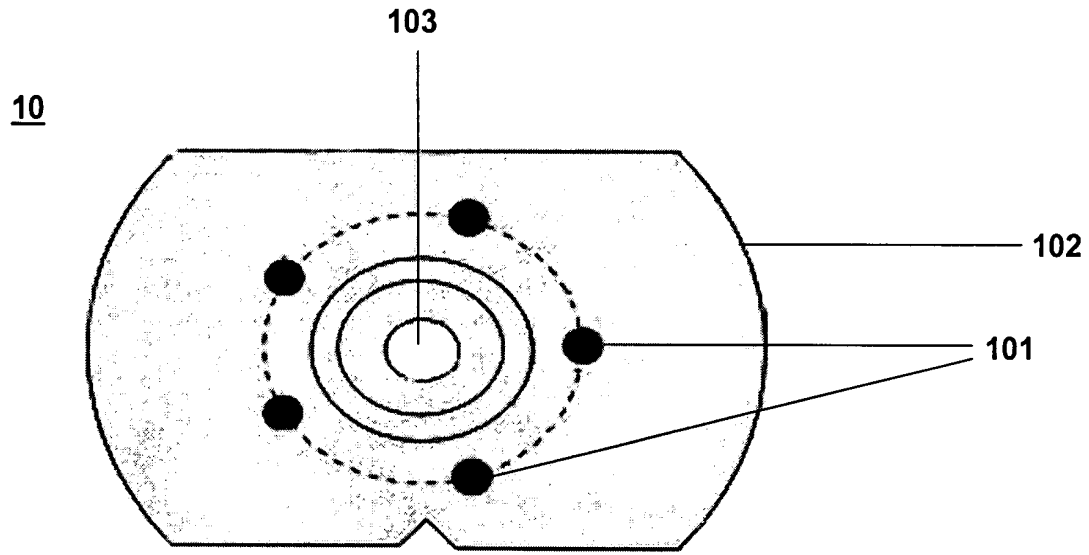


Figure 5

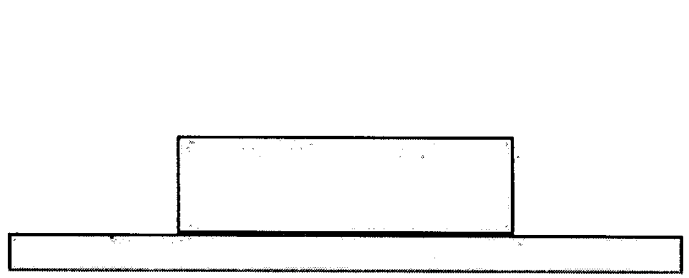


Figure 6

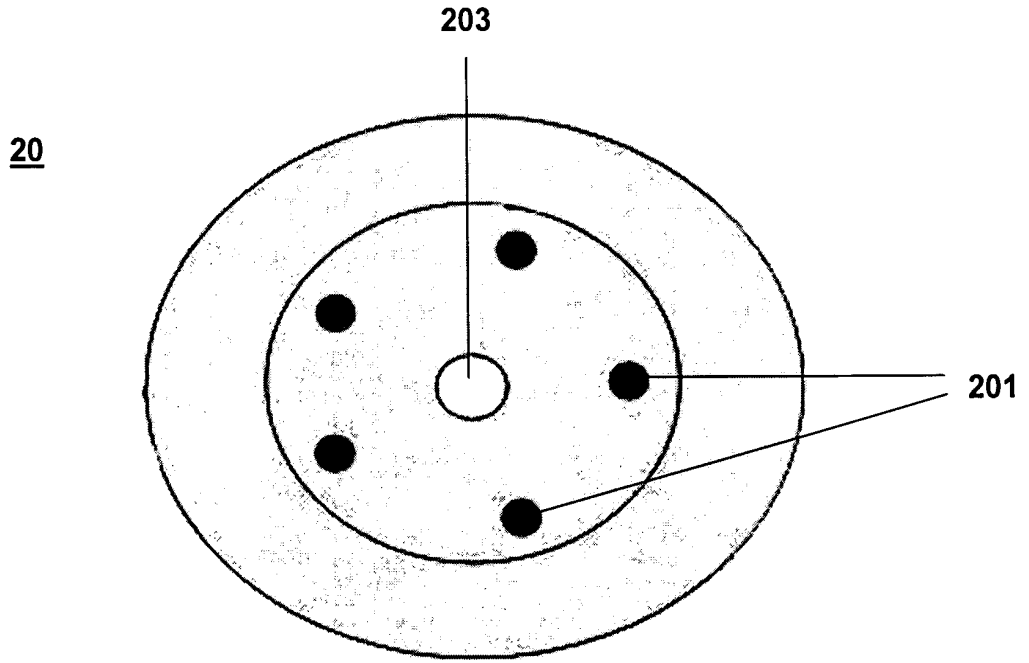


Figure 7

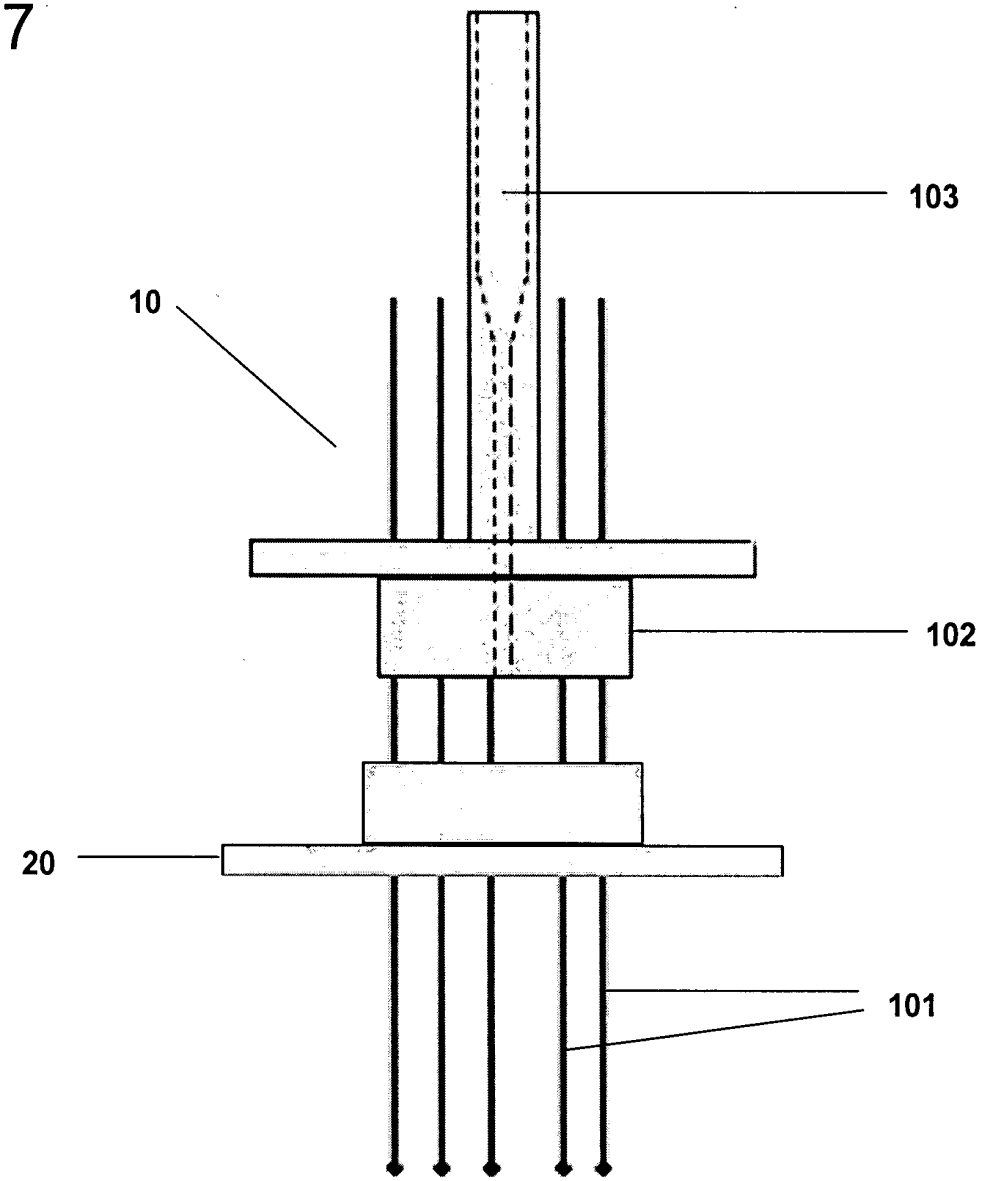
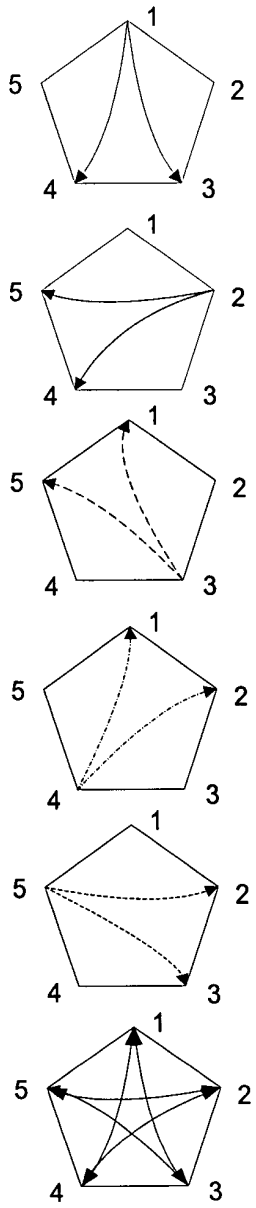


Figure 8

Program 0000

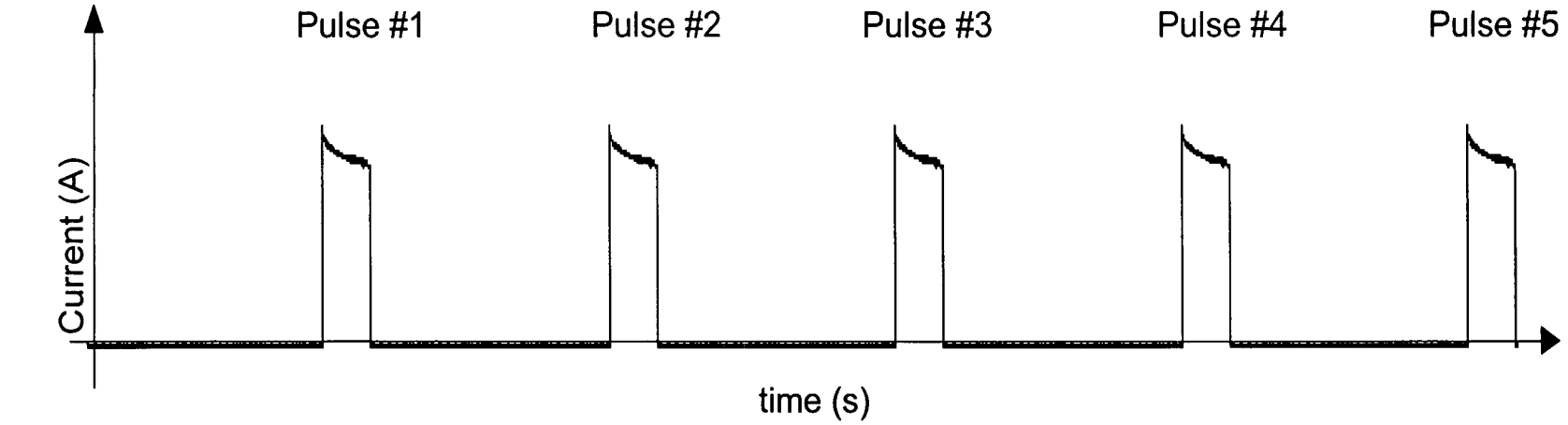


Pulse number	positive		negative	code
1	1	——→	3,4	PONNO
2	2	·····→	4,5	OPONN
3	3	— — →	5,1	NOPON
4	4	-·-·-→	1,2	NNOPO
5	5	- - - - →	2,3	ONNOP

composite

PONNO-OPONN-NOPON-NNOPO-ONNOP

Figure 9


A
Pulse #1
Pulse #2
Pulse #3
Pulse #4
Pulse #5
Current (A)
time (s)

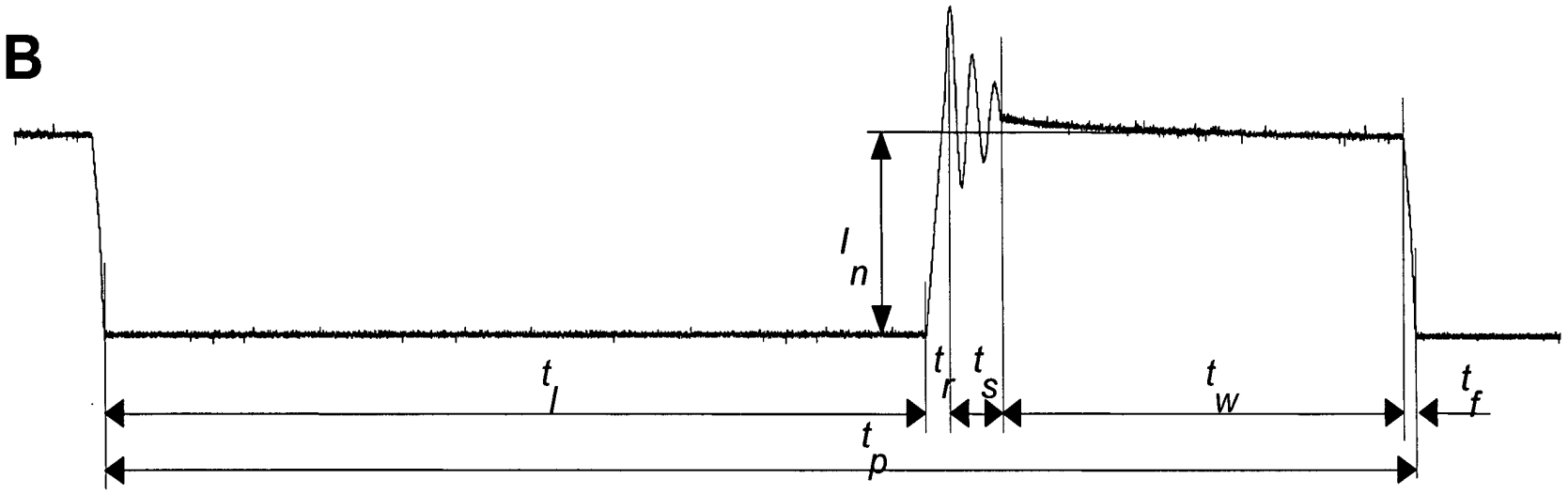
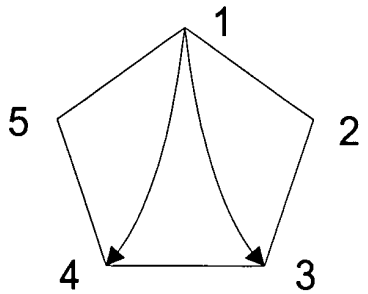
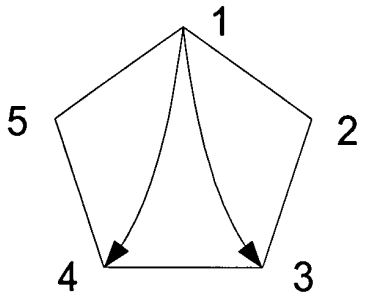

B
I_n
t_l
t_r
t_s
t_w
t_f
t_p

Figure 10

Program 0001





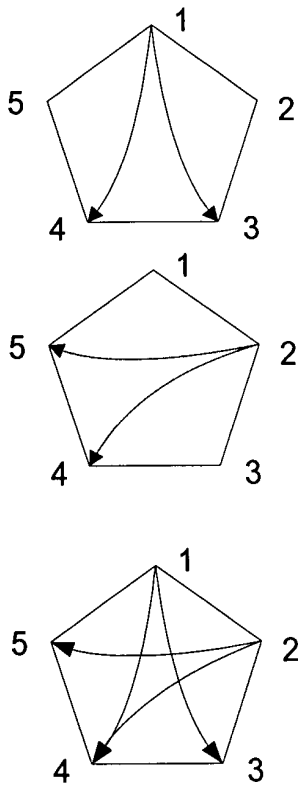
Pulse number	positive	negative	code
1	1 →	3,4	PONNO

composite

PONNO

Program 0002

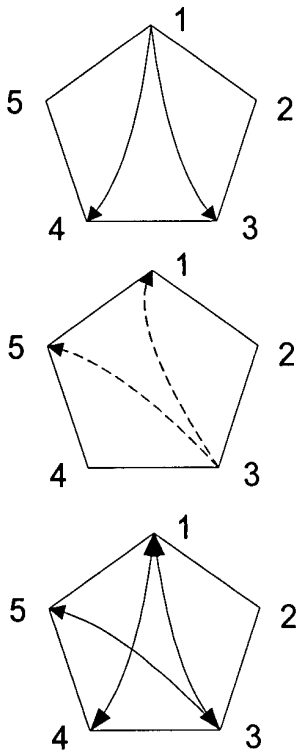
Figure 11



Pulse number	positive	negative	code
1	1 →	3,4	PONNO
2	2 ⇢	4,5	OPONN
composite			PONNO-OPONN

Figure 12

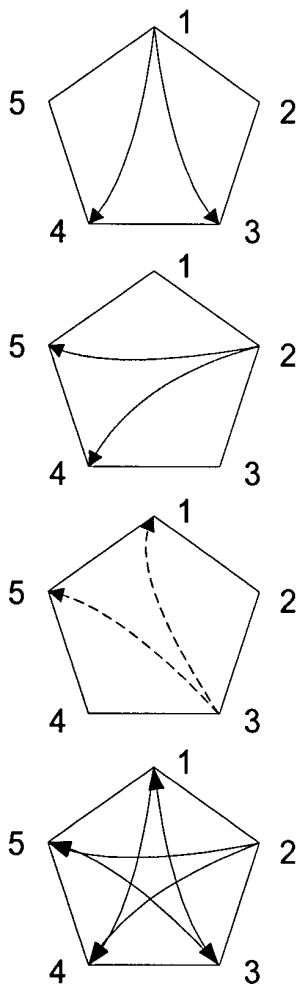
Program 0003



Pulse number	positive		negative	code
1	1	→	3,4	PONNO
2	3	- - →	5,1	NOPON
composite				PONNO-NOPON

Figure 13

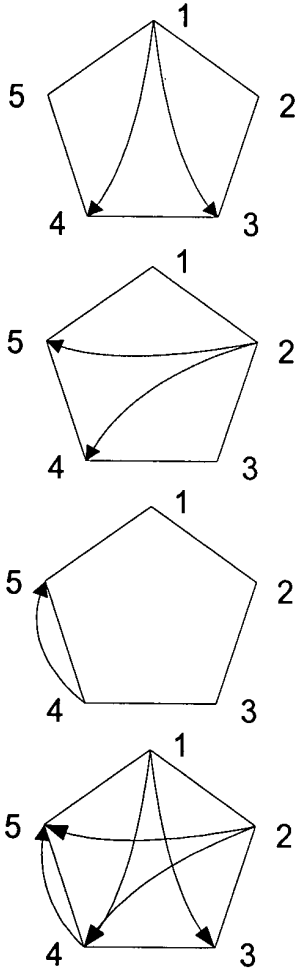
Program 0004



Pulse number	positive	negative	code
1	1 ——→	3,4	PONNO
2	2 ·····→	4,5	OPONN
3	3 — — →	5,1	NOPON
composite	PONNO-OPONN-NOPON		

Figure 14

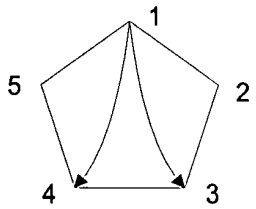
Program 0005

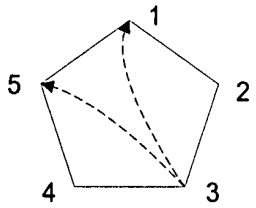


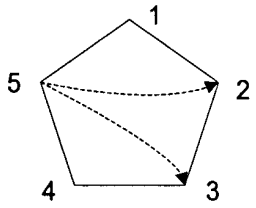
Pulse number	positive		negative	code
1	1	——→	3,4	PONNO
2	2	·····→	4,5	OPONN
3	4	– · – · →	5	OOOPN
composite	PONNO-OPONN-OOOPN			

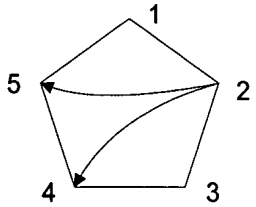
Figure 15

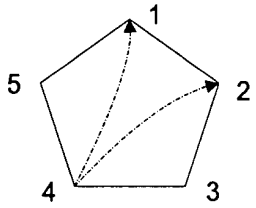
Program 0006

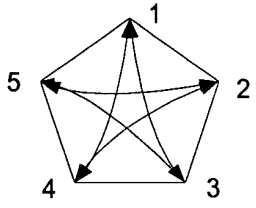












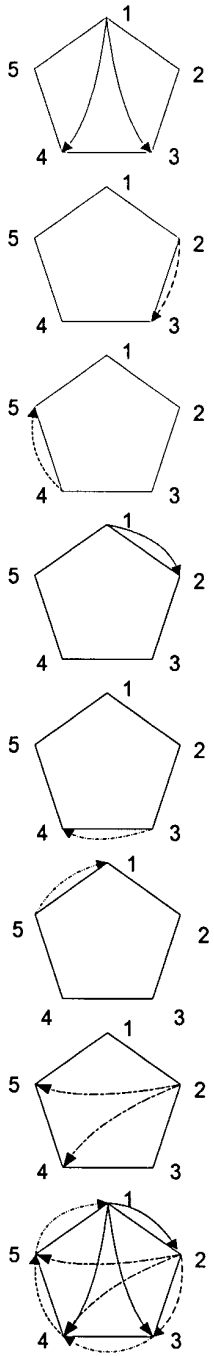
Pulse number	positive		negative	code
1	1	——►	3,4	PONNO
2	3	— — ►	5,1	NOPON
3	5	- - - - ►	2,3	ONNOP
4	2	·····►	4,5	OPONN
5	4	-·-·-·►	1,2	NNOPO

composite

PONNO-NOPON-ONNOP-OPONN-NNOPO

Figure 16

Program 007

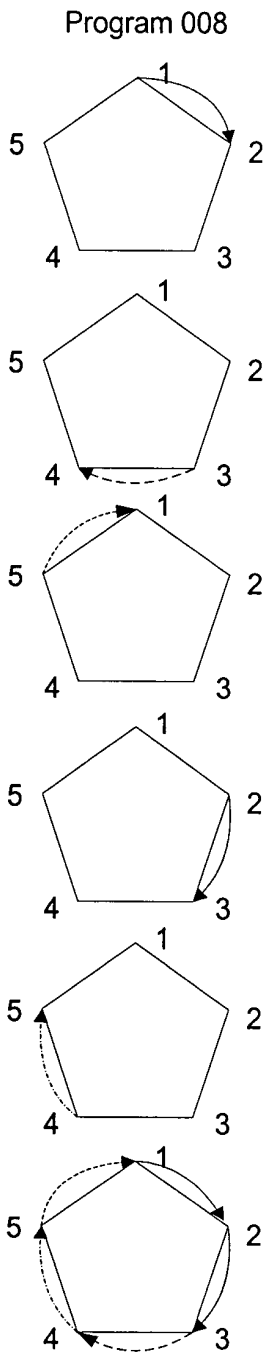


Pulse number	positive	negative	code
1	1	3,4	PONNO
2	2	3	OPNOO
3	4	5	OOOPN
4	1	2	PNOOO
5	3	4	OOPNO
6	5	1	NOOOP
7	2	4,5	OPONN

composite

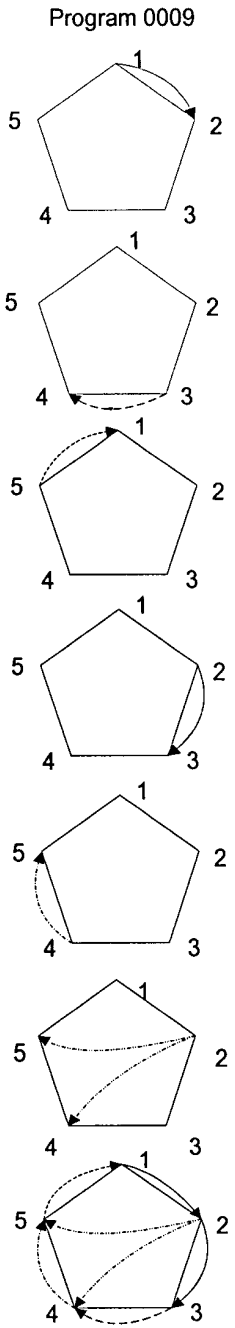
PONNO-OPNOO-OOOPN-PNOOO-OOPNO-
NOOOP-OPONN

Figure 17



Pulse number	positive	negative	code
1	1	2	PNOOO
2	3	4	OOPNO
3	5	1	NOOOP
4	2	3	OPNOO
5	4	5	OOOPN
composite			PNOOO-OOPNO-NOOOP-OPNOO-OOOPN

Figure 18



Pulse number	positive	negative	code
1	1 →	2	PNOOO
2	3 ⇢	4	OOPNO
3	5 ⇢	1	NOOOP
4	2 →	3	OPNOO
5	4 ⇢	5	OOOPN
6	2 ⇢	4,5	OPONN

composite

PNOOO-OOPN-NOOOP-NPON-OOOPN-OPONN

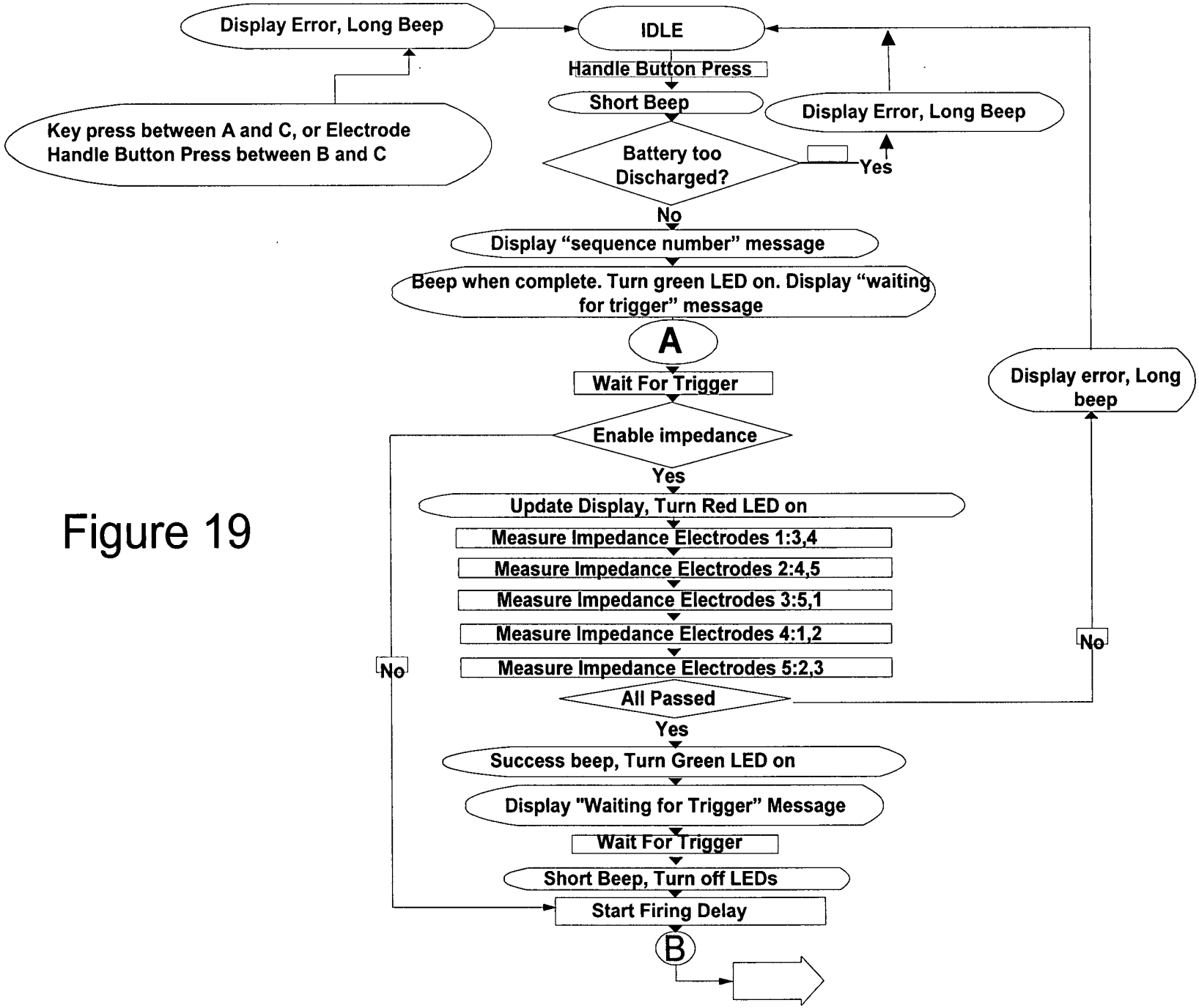

Display Error, Long Beep
IDLE
Handle Button Press
Short Beep
Display Error, Long Beep
Key press between A and C, or Electrode
Handle Button Press between B and C
Battery too Discharged?
Yes
No
Display "sequence number" message
Beep when complete. Turn green LED on. Display "waiting for trigger" message
A
Wait For Trigger
Display error, Long beep
Enable impedance
Yes
Update Display, Turn Red LED on
Measure Impedance Electrodes 1:3,4
Measure Impedance Electrodes 2:4,5
Measure Impedance Electrodes 3:5,1
Measure Impedance Electrodes 4:1,2
Measure Impedance Electrodes 5:2,3
No
No
All Passed
Yes
Success beep, Turn Green LED on
Display "Waiting for Trigger" Message
Wait For Trigger
Short Beep, Turn off LEDs
Start Firing Delay
B

Figure 19

Figure 20

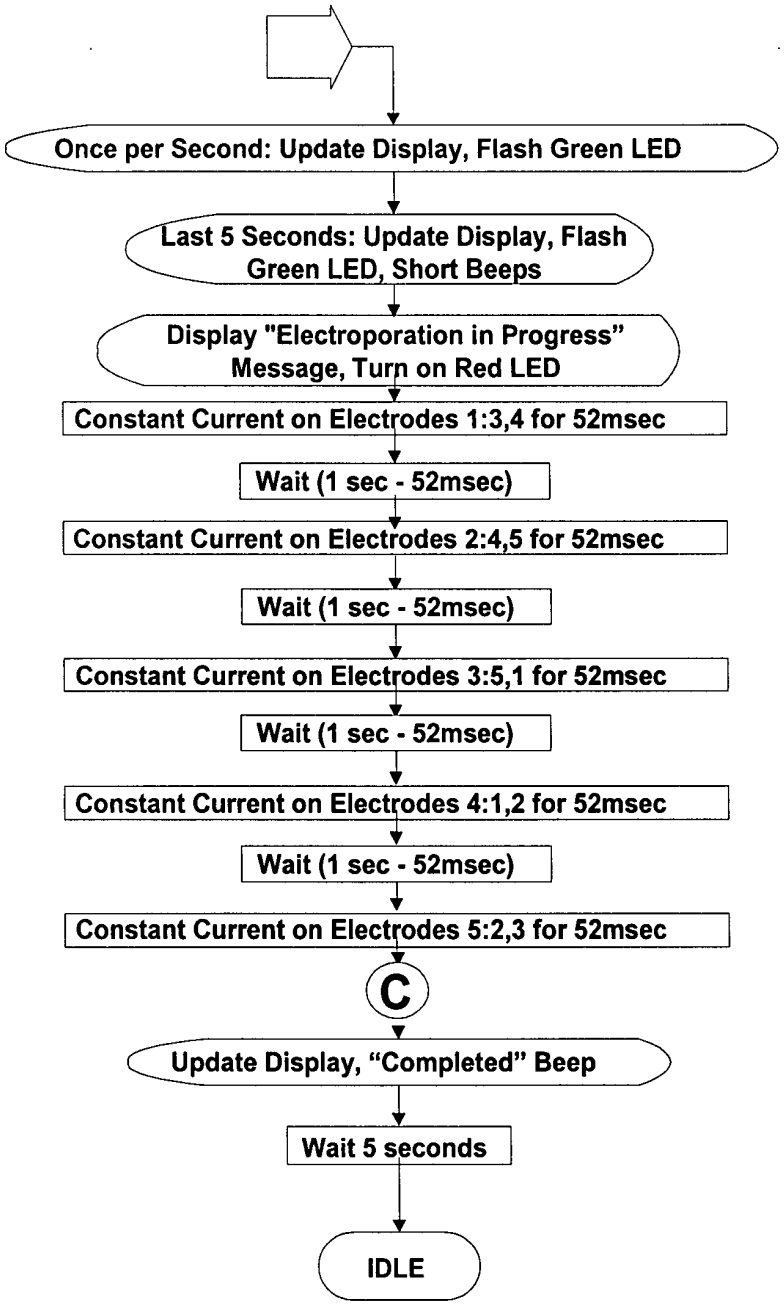

Once per Second: Update Display, Flash Green LED
Last 5 Seconds: Update Display, Flash Green LED, Short Beeps
Display "Electroporation in Progress" Message, Turn on Red LED
Constant Current on Electrodes 1:3,4 for 52msec
Wait (1 sec - 52msec)
Constant Current on Electrodes 2:4,5 for 52msec
Wait (1 sec - 52msec)
Constant Current on Electrodes 3:5,1 for 52msec
Wait (1 sec - 52msec)
Constant Current on Electrodes 4:1,2 for 52msec
Wait (1 sec - 52msec)
Constant Current on Electrodes 5:2,3 for 52msec
C
Update Display, "Completed" Beep
Wait 5 seconds
IDLE

Figure 21

Filename:	00001138_03_08_13_16_16_02.csv				
Animal Number:	1138				
Pulse In Sequence:	1	2	3	4	5
Pre-wait (s):	80	1	1	1	1
Pulse Width (ms):	52	52	52	52	52
Pulse Current (A):	0.5	0.5	0.5	0.5	0.5

Figure 22

Electrode 1:	POS	OFF	NEG	NEG	OFF
Electrode 2:	OFF	POS	OFF	NEG	NEG
Electrode 3:	NEG	OFF	POS	OFF	NEG
Electrode 4:	NEG	NEG	OFF	POS	OFF
Electrode 5:	OFF	NEG	NEG	OFF	POS

Figure 23

Pulse 1		Pulse 2		Pulse 3		Pulse 4		Pulse 5	
Voltage	Current	Voltage	Current	Voltage	Current	Voltage	Current	Voltage	Current
2.34	0	2.3	0	2.34	0	2.3	0	2.34	0
2.39	0	2.34	0	2.39	0	2.34	0	2.34	0
2.3	0.49	68.25	0.51	2.34	0.5	54.47	0.5	62.09	0.5
69.08	0.49	66.73	0.51	55.98	0.5	53.79	0.5	58.28	0.5
69.03	0.5	66.24	0.51	55.5	0.51	53.25	0.51	57.89	0.48
69.61	0.51	66.78	0.5	55.4	0.49	53.49	0.51	57.3	0.5
69.81	0.5	67.12	0.49	55.3	0.51	53.44	0.51	57.3	0.5
70	0.5	67.42	0.51	55.25	0.5	53.54	0.5	57.5	0.5
70.84	0.5	66.93	0.49	54.81	0.52	53.83	0.49	57.89	0.51
71.28	0.48	67.76	0.51	54.96	0.49	54.57	0.49	57.79	0.49

Figure 24

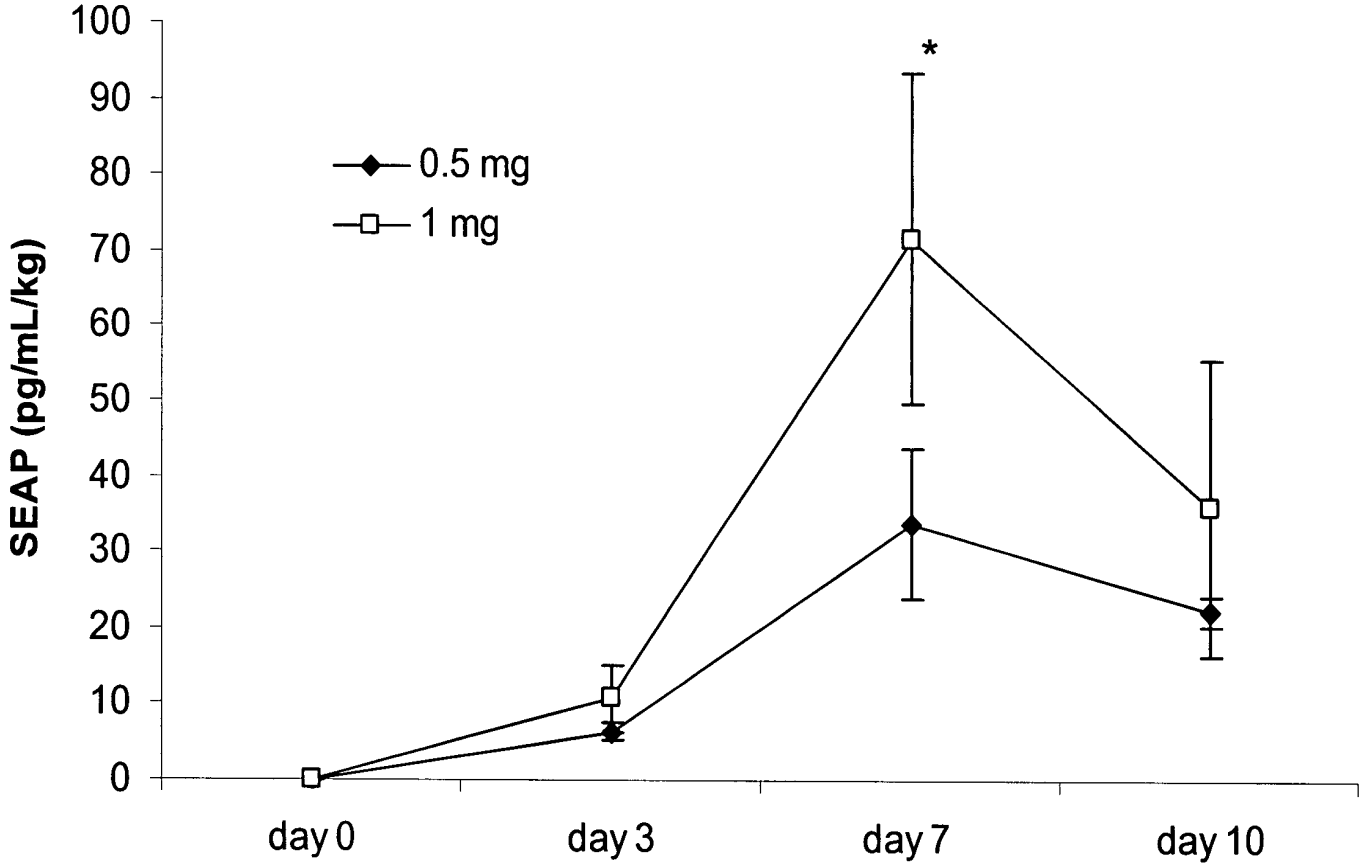

100
90
80
70
60
50
40
30
20
10
0
SEAP (pg/mL/kg)
0.5 mg
1 mg
*
day 0
day 3
day 7
day 10

Figure 25

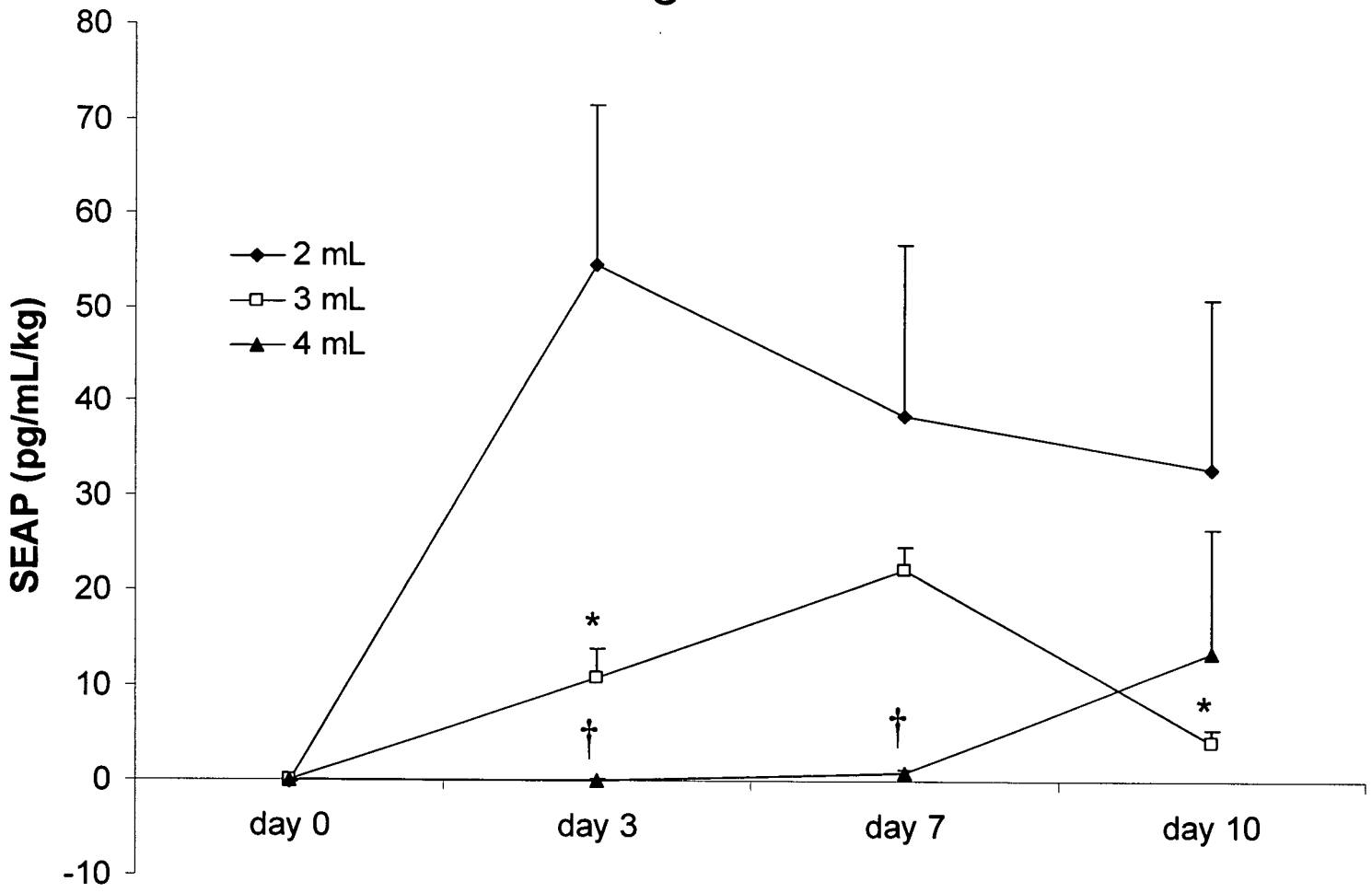

80
70
60
50
40
30
20
10
0
-10
SEAP (pg/mL/kg)
2 mL
3 mL
4 mL
*
†
†
*
day 0
day 3
day 7
day 10

Figure 26

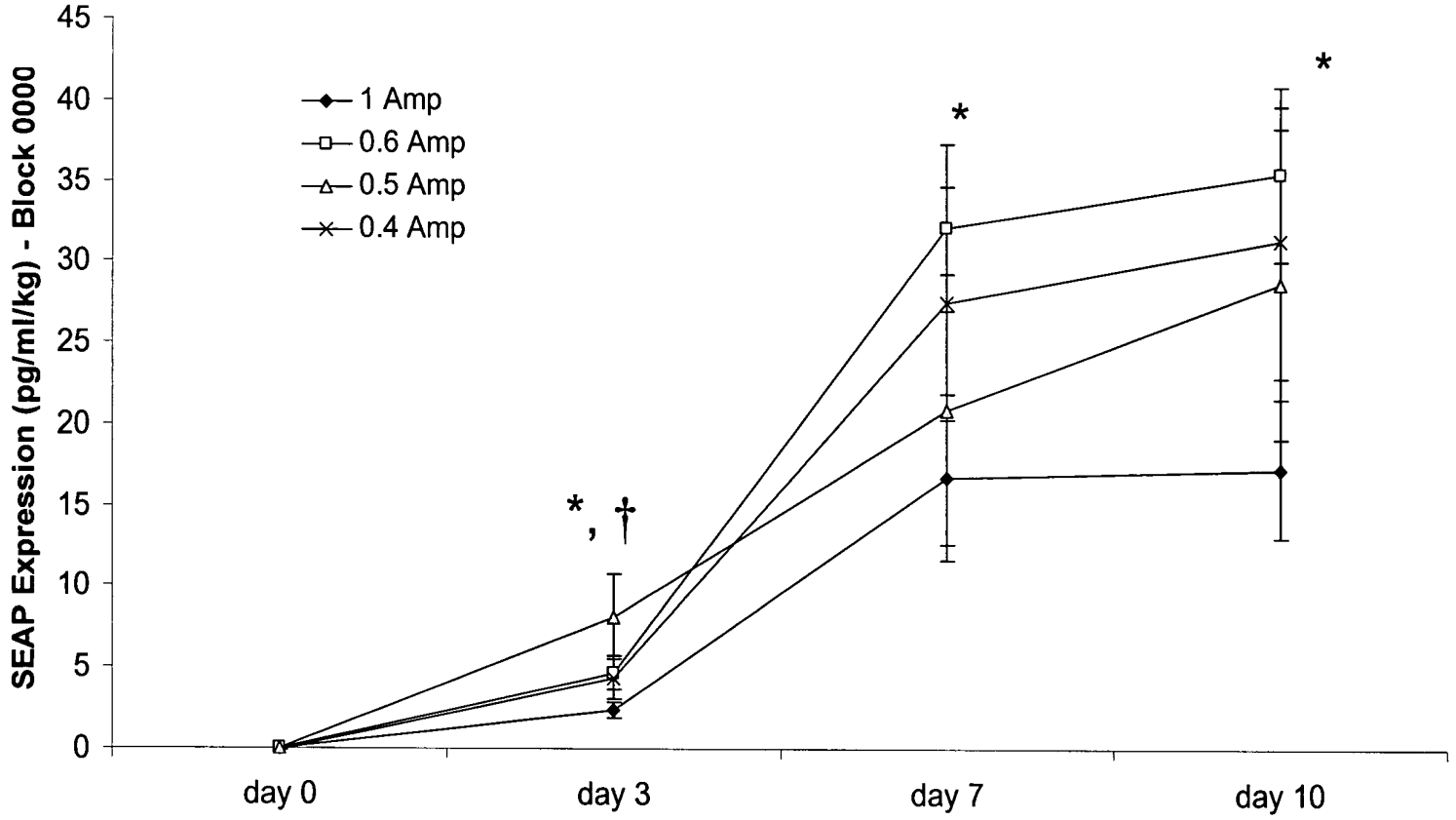

SEAP Expression (pg/ml/kg) - Block 0000
45
40
35
30
25
20
15
10
5
0
1 Amp
0.6 Amp
0.5 Amp
0.4 Amp
*, †
*
*
day 0
day 3
day 7
day 10

Figure 27

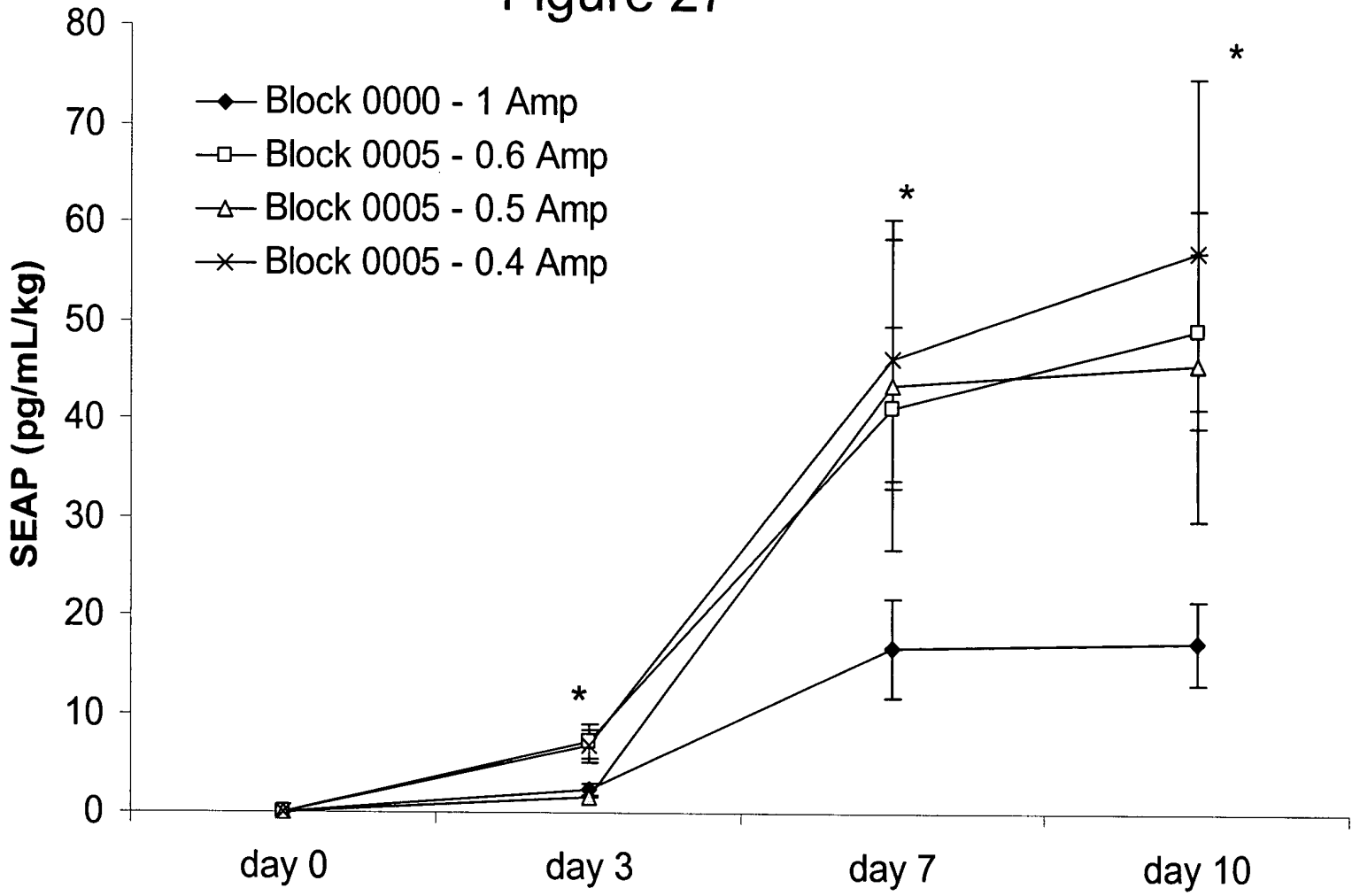

80
70
60
50
40
30
20
10
0
SEAP (pg/mL/kg)
Block 0000 - 1 Amp
Block 0005 - 0.6 Amp
Block 0005 - 0.5 Amp
Block 0005 - 0.4 Amp
*
*
*
day 0
day 3
day 7
day 10

Figure 28

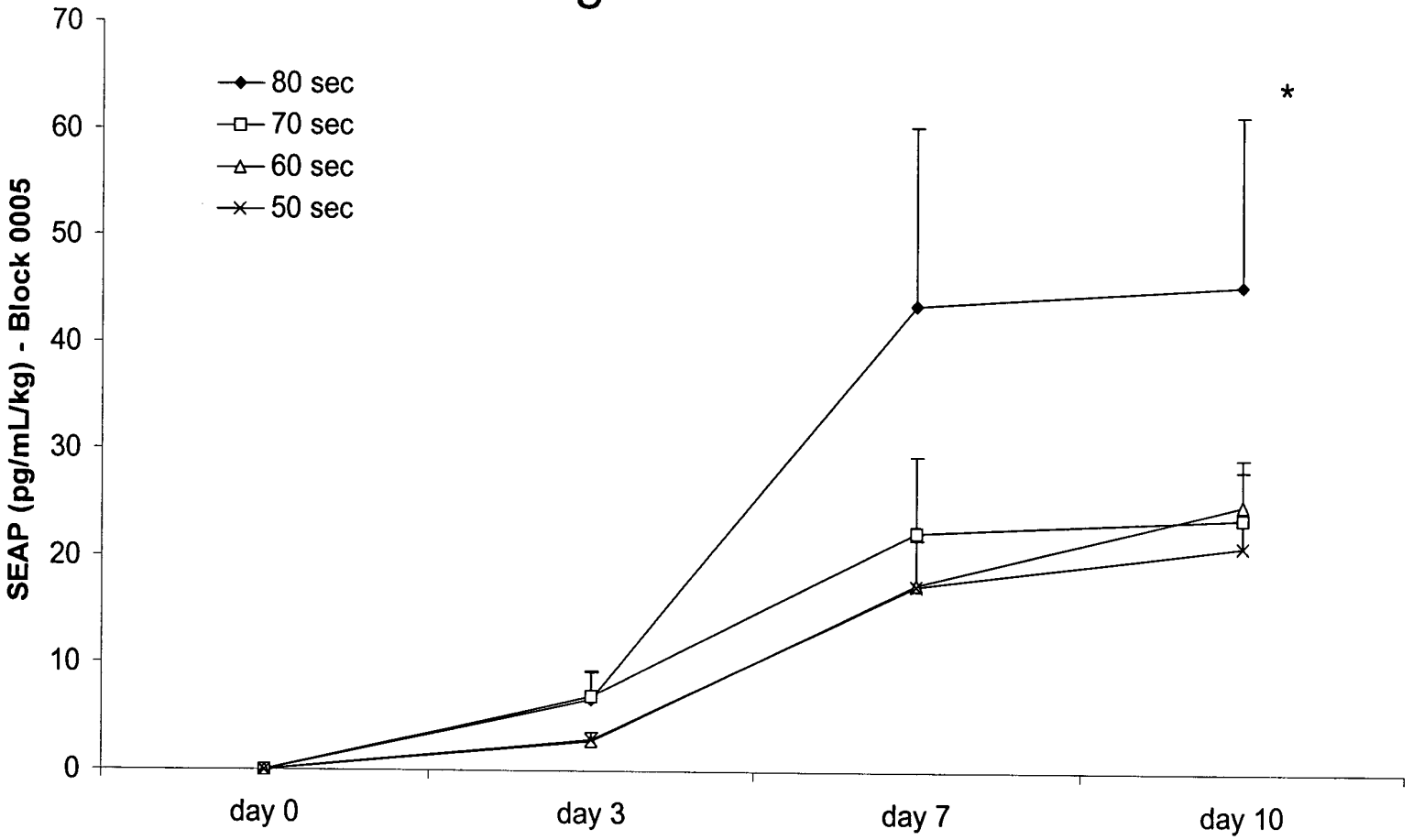

70
60
50
40
30
20
10
0
SEAP (pg/mL/kg) - Block 0005
80 sec
70 sec
60 sec
50 sec
*
day 0
day 3
day 7
day 10

Figure 29

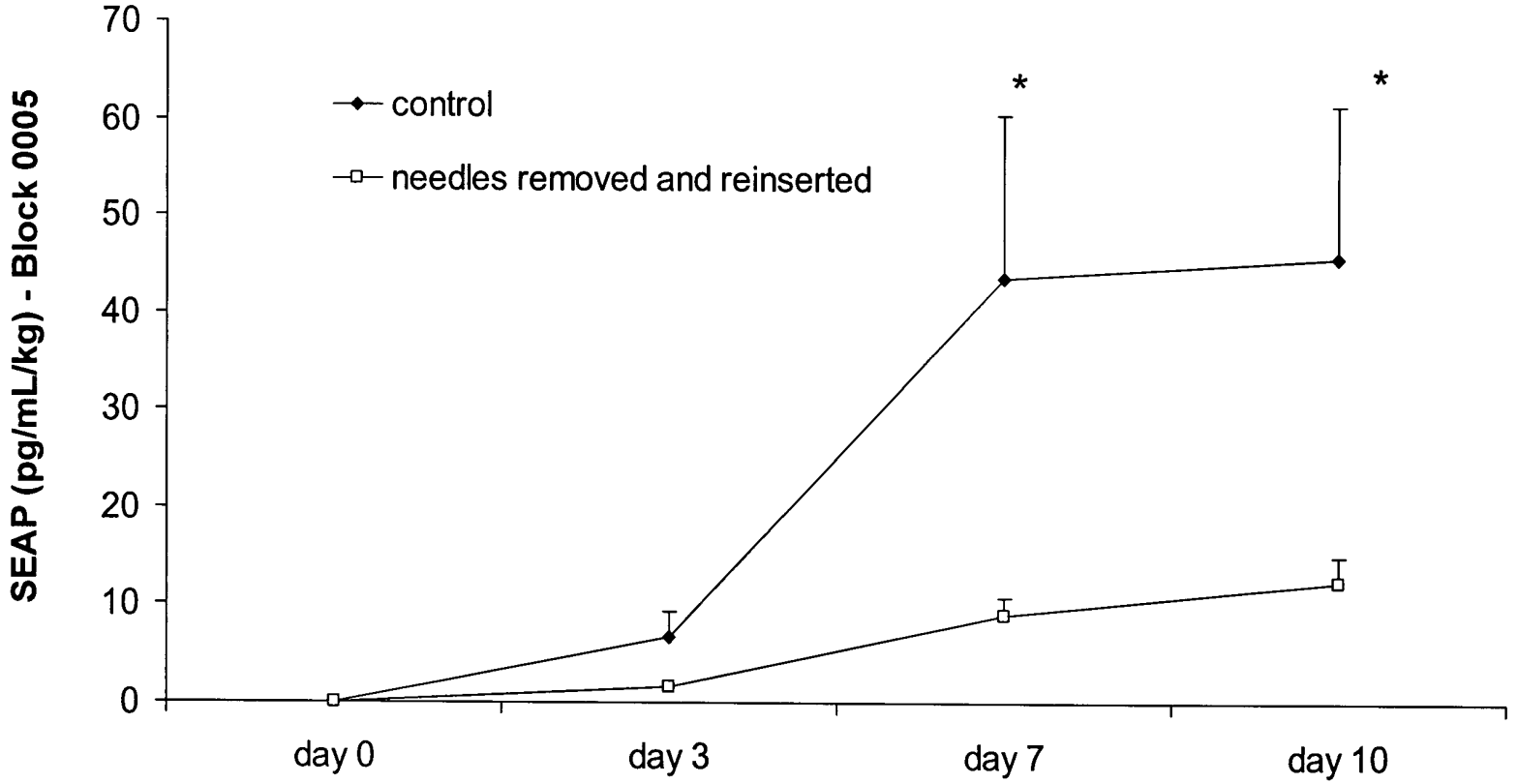
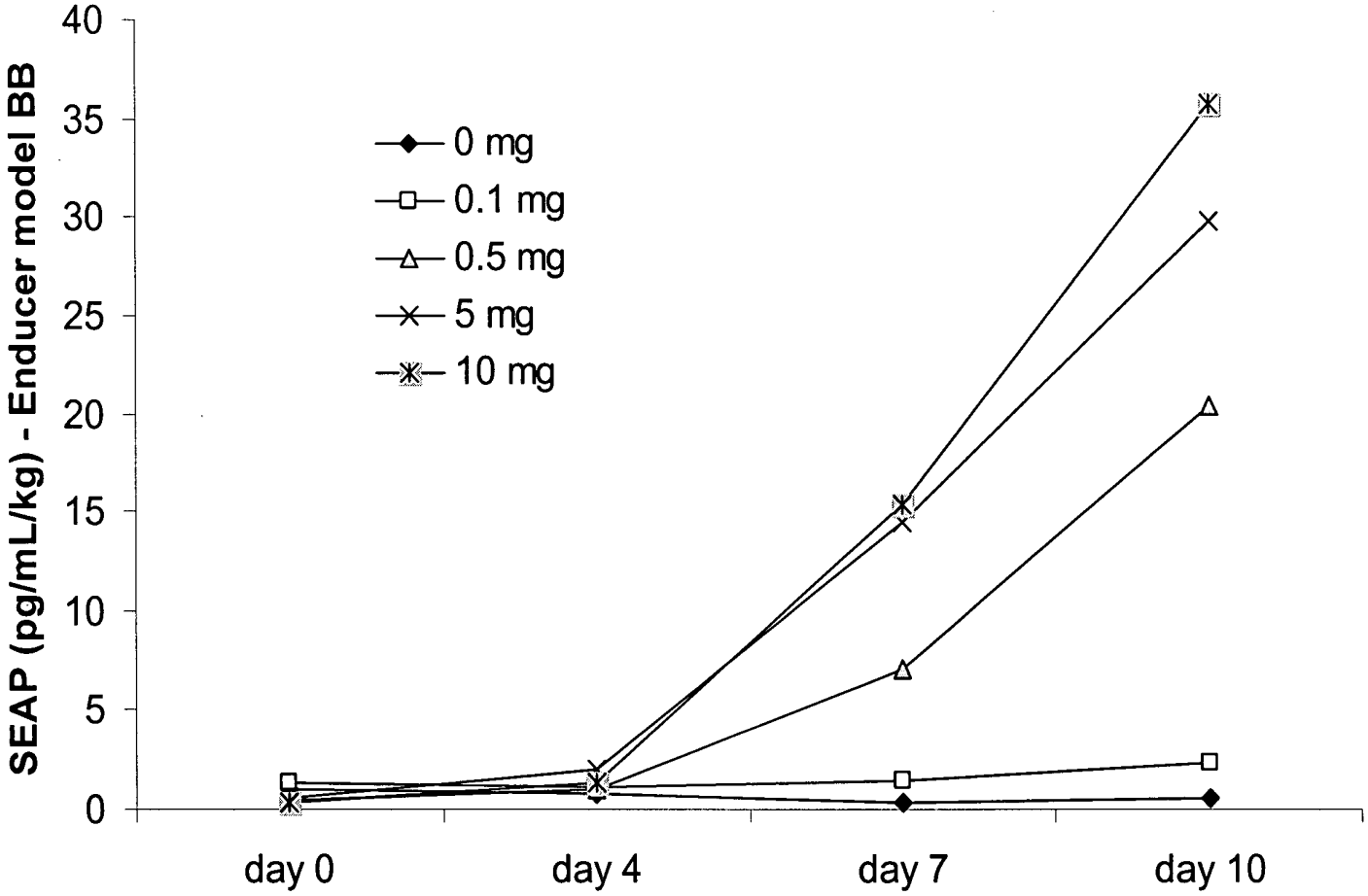

SEAP (pg/mL/kg) - Block 0005
70
60
50
40
30
20
10
0
control
needles removed and reinserted
*
*
day 0
day 3
day 7
day 10

Figure 30


SEAP (pg/mL/kg) - Enducer model BB
40
35
30
25
20
15
10
5
0
0 mg
0.1 mg
0.5 mg
5 mg
10 mg
day 0
day 4
day 7
day 10